学校编码：10384　　分类号_____密级 _____

学号：15620090153433　　UDC _____

厦门大学

博 士 学 位 论 文

外汇期权中的隐含相关性：预测及其应用

Implied Correlation in Foreign Exchange Options: Forecasting and its Application

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论文提交日期：　2013 年 4 月

论文答辩日期：　2013 年　 月

学位授予日期：　2013 年　 月

答辩委员会主席：_____

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2013 年 4 月

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摘　要

汇率是投资者使用不同货币在全球范围内进行投资的纽带，汇率的变动直接影响到投资者跨国资产配置时的投资决策及最终投资收益的实现，然而汇率不仅仅通过自身的变动对资产组合起作用，各国货币汇率之间相关性的变动也是汇率影响资产组合风险的重要渠道。在现实世界中，汇率之间的相关性时时刻刻都在变化，这就给投资者的资产组合带来了额外的系统性风险，如何能够准确的预测汇率之间的相关性及其变化对投资者来说至关重要。但是，汇率之间的相关性本身是无法精确观测更是很难准确预测的，传统的历史预测方法由于其中并没有包含投资者对未来的预期，所以预测偏差往往很大。本文利用了期权在反映投资者预期方面的优势，采用外汇期权的隐含波动率报价提取出能够包含投资者对未来预期的期权隐含相关系数，并利用提取出的隐含相关系数进行了预测及其应用方面的研究。

基于外汇现汇汇率之间满足无套利的三角关系的基本假设，本文利用统计学中两变量之和的方差公式经过变形得出了汇率之间的隐含相关系数。本文以欧元兑美元和日元兑美元两种汇率之间的相关系数作为实证研究的研究对象，对它们之间相关性的预测进行了研究。包括已实现相关系数序列在内，本文还得到了历史相关系数序列、指数加权平均相关系数序列及隐含相关系数序列共四种相关系数序列。将已实现相关系数序列作为现实世界相关系数的代理，本文比较了各相关系数序列对已实现相关系数序列的预测能力。比较的结论显示，无论是在全样本还是市场大幅度波动样本期，外汇期权隐含相关系数相比于历史相关系数都显示出了预测方面的优势，对组合预测的分析也发现，不同信息的组合预测有利于预测能力的改善。

利用代表现实世界的已实现相关系数序列与代表风险中性世界的隐含相关系数序列之间的差异，本文得到了汇率的相关性风险溢酬序列。对相关性风险溢酬属性的分析表明，所有期限的相关性风险溢酬均值显著为负，对相关性风险溢酬的断点效应分析发现，1 月期和 3 月期的相关性风险溢酬在金融危机发生前后的断点效应比较显著，而 6 月期和 1 年期的断点效应却并不明显。另外，不同期限的相关性风险溢酬序列之间均为显著正相关，并且 6 月期和 1 年期的

风险溢酬序列之间的相关性相对比较高，而 1 月期和 1 年期的风险溢酬序列之间的相关性则相对最低。对相关性风险溢酬序列信息含量分析的结果发现，相关性风险溢酬中包含了汇率的方差风险溢酬和利率的信息。

本文分别采用了损失函数模型和已实现效用模型来分析汇率相关性的预测在资产配置中的应用。对 WRMSPE 的分析结果显示，考虑了波动率加权的预测偏差结果仍然支持短期（1 个月）和中期（3 个月和 6 个月）隐含相关系数的预测能力优于历史相关系数，但不同的是长期（1 年）历史相关系数的预测能力优于隐含相关系数。已实现效用模型的结果表明，只有中度和高度风险厌恶投资者愿意为了获取期权的隐含相关系数信息而付出一定的信息成本，轻度风险厌恶者则更倾向于选择历史相关系数作为对未来汇率之间相关系数的预测。进一步地，本文利用分区间分析发现，当市场处于意外的急剧下跌状态时，所有类型的投资者都会更倾向于（中度或高度风险厌恶者）或者无差异（轻度风险厌恶者）地选择隐含相关系数作为对未来汇率之间相关性的预测，而当市场处于上涨或震荡波动状态时，与全样本时的结论一样，只有中度或者高度风险厌恶者才会愿意支付一定的信息成本去获得隐含相关系数的信息。

关键词：汇率；隐含相关性；预测；相关性风险溢酬；资产配置

Abstract

Foreign exchange rate plays an important link role when investors participate in the global economic activities with return denominated in different currencies. The exchange rate variations have a great influence not only on the investors' decision making when allocating their global assets versus security selection, market timing and other factors, but also on the final return denominated in their home currency. Exchange rate affects the global portfolio not just by its own variations, the change of correlations among different exchange rates also adds an systematic risk to the investors' portfolios. In the real world, correlations change every seconds accompany with the change of exchange rates themselves and thus it is very important for the investors to make a quick and precise judgment on what the correlation will be during the next second. However, neither the measure nor the prediction of the correlations can be easily realized. In traditional studies on the forecasting of economic variables, it is always common to use the historical methods in their forecasting even the historical predictions perform rather poorly compared with the realized variables. The reason why historical prediction methods did a poor job can be ascribed to its using of totally past information and lack of messages about investors' expectations for the future market's performance. To solve this problem and make an improvement on the forecast performance, this paper takes an advantage of the option trading activities which is believed to contain anticipating information and uses the OTC quoted implied volatility prices to extract the implied correlations between exchange rates. With the option-implied exchange rate correlations series, this paper makes a progressive research on both the forecasting work of exchange rates' correlations and its applications in global portfolio management.

On the basic assumption of the no-arbitrage triangular relationship among the related three spot foreign exchange rates, this paper uses the transition of the variance formula for the sum of variables in statistics and the quoted implied volatility prices from the OTC market to calculate the option-implied correlation

between two exchange rates. In the empirical part, the EURUSD rate and JPYUSD rate are used as the instrument rates and the correlation between them are discussed in detail through the whole paper. Including realized exchange rate correlation series, which is used as a proxy for the correlation in the physical world, four correlation series are calculated and their forecasting ability are compared respectively in one, three, six and twelve months. Results of the comparison show that the implied correlation series predicts more precisely than both the historical correlation series and the EWMA correlation series when the full samples are used, as well as when only the more volatile samples are used. What is more, the combination of the historical correlation series and the implied correlation series is also calculated and it is shown that the combination of different information used as a new forecast can improve the forecasting ability of the individual forecasts significantly.

This paper then makes a thorough discussion of the foreign exchange rate correlation risk premium, which is defined as the difference between the correlation in the physical world and the correlation in the risk-neutral world. Analyzing the characteristics of the four correlation risk premium series in different terms both as time series and a term structure, it is found that the time series mean of the four series are all significantly negative, which seems reasonable to our economic sense. Break point analysis for the correlation risk premium series shows that short term series (1-month and 3-month) behave differently when using the declaration bankruptcy of the Lehman Brothers Holdings Inc. in 2008 as a break point standing for the getting worse of the US subprime crises, while long term series (6-month and 1-year) behave no such break point effects. The correlation risk premium series in different terms behave highly positive-correlated with a higher correlation between the 6-month and 1-year risk premium series and a lower correlation between the 1-month and 1-year risk premium series. Moreover, principal analysis of the term structure of the correlation risk premium series shows almost the same covariance structure as that of the interest rate. Information analysis of the correlation risk premium series illustrates a close relationship between the correlation risk premium series and the variance risk premium series as well as the currency interest rates.

Forecasting ability of different correlation series is then discussed through its application in global asset allocation and this can be an economic verification for the correlation forecasting. The Loss Function Model and the Realized Utility Model are used for this purpose. Results of the analysis for the WRMSPE show that，the variance-weighted prediction error supports the advantage of the implied correlation over the historical correlation for the 1-month, 3-month and the 6-month correlation forecasting but supports the contrary for the 1-year correlation forecasting. Results of the Realized Utility Model show that, investors with middle and high risk aversion are willing to pay some positive cost for the information of the option-implied correlation when forecasting the exchange rate correlation, while investors with low risk aversion is not willing to do so and they would rather use the historical correlation instead. Dividing the whole samples into two parts, the severely downward samples and other samples, this paper does a partition analysis to analyze the deep reasons for the information chosen behavior. Results of the partition analysis show that, investors of all types will prefer or make no difference to choose the implied correlation as their prediction for the future exchange rate correlation when using the severely downward samples, while only investors with middle and high risk aversion are willing to choose the implied correlation as their prediction when using the other samples, the same as the results when full samples are used.

Keywords: foreign exchange rate; implied correlation; forecasting; correlation risk premium; asset allocation

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